In attempting to estimate correctly the amount of energy used for the actual forward progression of the body it is essential to deduct from the total measured energy output a fraction which will represent what may be termed the basal maintenance metabolism, and it is somewhat difficult to decide what value to take for this purpose. The authors on the whole prefer to take as this basis the energy output found when the subject is standing still with the muscles relaxed, and this value certainly appears more reasonable than that found when the subject is lying at rest, though the latter has been used frequently by earlier workers on the subject. They have, however, considered other possible bases, especially with reference to walking at a very fast pace when pronounced movements of the arms occur.

With one of the subjects the pace was limited to slightly under three miles an hour, but with the other it was varied widely, ranging, roughly, from two and a half to five and a half miles an hour. As the pace increases the amount of energy output to move one kilo of the body weight one metre horizontally increases very greatly, as other observers have found. Some experiments performed with the subject running showed that it was more economical of energy to run than to walk at the rate of more than five miles an hour.

In examining the influence of food on the energy output during the exercise, the authors find that the increase in the metabolism due to the walking is at any given pace in the main constant and merely superimposed on the increased resting metabolism due to the food. With a large protein diet there is evidence that the heat output per unit of work is increased. Apart from the question of the absolute expenditure of energy, the figures in the various tables will be of extreme interest to any who wish to study the character of the metabolism during muscular exertion.

C. G. D.

THE GRAVELS OF EAST ANGLIA.

THE Cambridge University Press has published two interesting geological pamphlets by Prof. T. McKenny Hughes, the first on "The Gravels of East Anglia" (price 1*s.*), the second entitled "Notes on the Fenland," with a description of the Shippea man by Prof. A. Macalister (price 6*d.*). The gravels of East Anglia are especially useful in any inquiry as to the age and origin of the superficial deposits of our country, because of their wide distribution and the long continuous sections on the coast, in which many of them may be studied. They consist for the most part of subangular flints, which cannot have been derived directly from the chalk, and Prof. Hughes concludes that they are the débris of an old Miocene land-surface on which the chalk with flints was exposed. After a well-illustrated account of many sections, and a brief discussion of the mammalian remains found in the gravels and associated deposits, Prof. Hughes summarises the sequence of phases in the later geological history of East Anglia as he now understands them. All these gravels are of Pleistocene age, but the marsh-deposits of the fenland are distinctly later. They contain remains of the brown bear and the beaver, which survived in England until historic times, but none of the typical Pleistocene mammalia; while the most remarkable of the birds is the pelican. There is no definite chronological succession which will hold throughout the fens, and the relative dates of the various remains found in them cannot be well determined. The human skull and associated remains from Shippea Hill, described by Prof. Macalister, may be quite modern, though perhaps as old as the Bronze age.

THE ORGANISATION OF INDUSTRIAL SCIENTIFIC RESEARCH.[1]

II.

IT is the common opinion of those who have to deal with the organisation of research that only a small percentage of all the investigations started are likely to be successful, the great majority being either dropped before they come to an end, or, being carried through, are filed simply as records, without any results having been obtained which would justify the expense of the investigation; that is to say, industrial research is justified only by the great value of the successful attempts, and these must bear the burden of a great number of unsuccessful attempts, which may have been quite as costly as the successful ones themselves. Naturally, the object of organisation is to attempt to reduce the proportion of unsuccessful investigations which will be undertaken, as has already been shown. This can be done by increasing the size of the laboratory, by increasing the specialisation of the workers, and especially by increasing co-operation between workers in different fields.

Naturally, the most important step which could be taken to increase the efficiency of industrial research would be to increase the likelihood of correct choice of a promising investigation, but, unfortunately, very little can be done in this direction. Those with the most experience in research work are all agreed that it is almost impossible to say whether a given investigation will prove remunerative or not. The only general conclusion that can be drawn is that the deeper a given investigation goes towards the fundamentals of the problem the more likelihood there is that the results will be of value, and the more superficial an investigation is, even although it appears more promising at first sight, the less likelihood there is that it will finally prove of real worth, so that the choice of investigations must necessarily be made largely at random, and will be influenced to a great extent by the ideas of the scientific workers themselves; if any worker has a desire to take up any particular line of work, provided that it is associated with the general trend of work in the laboratory, it is usually wise to let him do so, but the expedition with which a decision can be reached as to the probable value of the investigation after it has been started is very greatly enhanced by the complete co-operation of workers in the different branches of science in consultation on the problem.

At this point it might be well to discuss the organisation of a large research laboratory. Such a laboratory should be established in charge of a director who has had some actual manufacturing experience in the works processes, but at the same time he must have a considerable sympathy with purely scientific work and an interest in the advancement of scientific theory. *Both* these qualifications are desirable, but if such a director combining the two cannot be found, then a man of full scientific training should be chosen and put into a position of responsibility in the manufacturing side of the industry until he has become fully acquainted with the technique of the industry. It is most inadvisable to take a man from the industry who has not had a full scientific training, including advanced research work in academic problems, since he will generally be lacking in sufficient knowledge of, and sympathy with, the more academic investigations of which he will be in charge, and if the two necessary qualifications cannot be found united in one man, it will be necessary to take a man with the scientific qualifications and give him the practical training, which is just as essential for the director of a laboratory as scientific knowledge.

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[1] An address delivered at Columbia University by Dr. C. E. Kenneth Mees, director of the Research Laboratory, Eastman Kodak Co. Rochester N.Y. Continued from p. 413.

These necessary qualifications in the director are reflected in the division of the laboratory itself into manufacturing and scientific sections, since the manufacturing section should be able to carry out on a small scale all the chief manufacturing operations, so that any investigations made in the laboratory can be carried through to the practical works' scale without interfering with the production departments. In the research laboratory of the Eastman Kodak Company the manufacturing department includes emulsion-making and plate, film, and paper-coating departments, the capacity being very considerable, the plate department being able to make 300 dozen 8 in. by 10 in. plates a day. These departments are used not only for systematic experiments on emulsion suitable for various purposes, such as different kinds of plate emulsion, colour-sensitive emulsions, especially for colour photography, and experimental printing papers, but they are further used to make on a small scale products which are required for special purposes in very small quantities, such as special plates required by astronomers or spectroscopists, or special films required for experimental purposes by those working on colour photography, or attempting to develop other photographic processes. Requests for such special materials are received by every large manufacturing company, and the execution of the orders in the production departments frequently involves much delay and loss, whereas the manufacturing section of the laboratory can carry out the work with a full understanding of the use to which the materials are to be put, and can often materially assist the purchaser in working out his idea. Co-operation of this kind between the general public and the laboratory cannot but be of advantage to both parties.

The manufacturing departments should be in charge of skilled foremen who have had previous experience in the works, and be run in exactly the same way as the production departments themselves, being under the general supervision of the director of the laboratory and of any assistants that it may be necessary for him to employ. The foremen of the departments should, however, co-operate very fully with the scientific departments.

There is always some difficulty in a laboratory in getting the scientific departments to make full use of the special knowledge of the manufacturing division and at the same time to realise the practical difficulties which occur in works processes, but this difficulty can be overcome much better in the case of the manufacturing division of the laboratory than it could if an outside production department were involved without the laboratory division acting as intermediary.

The scientific division of the laboratory should be divided into departments dealing with the special subjects, but every care should be taken that these departments do not become at all isolated from each other, and that they co-operate with each other in the most complete way on the solution of the problems on which the laboratory is engaged. In order to ensure this the main lines of work under investigation may be suitably discussed at a morning conference at the beginning of the day's work, one day of the week being assigned to each subject. The laboratory organisation will then resolve itself into a number of different departments engaged in dealing with a number of different lines of work, and the total work of the laboratory during the year may be suitably represented by a chart similar to that devised for the research laboratory of the Eastman Kodak Company.

The departments of the laboratory are represented as circles on the outside of the chart, the main divisions in which problems group themselves being represented by rectangles, subdivided in some instances, occupying the middle of the chart. Each of these rectangles will correspond to a morning conference; thus, a conference will be held on general photography, at which there will be present members of the photographic department, the physics department, the department of organic chemistry, and the emulsion and coating or manufacturing departments. There will be present at the conference, in fact, every scientific worker of the laboratory, whatever his rank, who is directly engaged on the subjects which are included under the head of general photography, and in some cases, or on special occasions, members of the staff of the company external to the laboratory may be invited to these conferences, although as a general rule in the case of a large company it will not be possible for them to be regularly present. All the main lines of investigation should be laid down at these conferences, and the progress from week to week carefully discussed. This procedure will enable a great saving in time to be made, since it will avoid the loss of time which continually occurs in laboratories from the wrong man doing a specific piece of work; and the economy can be much increased by a suitable arrangement of the building and equipment itself.

The building should be so arranged that all the laboratories are open to everybody in the scientific departments, but that in each laboratory involving special classes of apparatus there are specialists continually working who are available for consultation and assistance to all other workers in the laboratory. In this way single operations which become necessary in the course of an investigation may frequently be transferred from the man who has carried on the main line of work on the subject to some other specialist in the laboratory. In the Kodak laboratory, for instance, electrical measurements, photometric measurements, spectrophotography, lens optics, photographic sensitometry, work involving dyestuffs, and all strictly photographic operations, such as copying, lantern-slide making, printing and enlarging, making up developers, etc., are in the hands of specialists, and whenever any of these operations become necessary in the course of an investigation, the conference directs that they be carried out by the specialist on the subject. In this way an organic chemist, for instance, will have the absorption curve of his products measured, not by an instrument in the organic laboratory, but by the physics department, while the preparation of photographs, lantern-slides, and prints, which are often involved in publication, are carried on by the photographic department and not by the man who did the work, these arrangements relieving specialists in one subject from having to acquire technical skill in another. It is in such complete co-operation that the greatest economy in scientific investigation is to be found.

It must be remembered that such specialisation as this is not at all suitable for use in a university, where the object is the broadening and education of the students; it is one of the many differences between research work in a university and in a set research laboratory, whether it be industrial or not, that in a university the primary object is the training of the worker, while in the research laboratory the primary object is the carrying out of the investigation.

The best utilisation of the results obtained in an industrial research laboratory is only second in importance to the organisation required to obtain them. All results of general scientific interest and importance should undoubtedly be published, both in the public interest, and because only by such publication can the interest of the laboratory staff in pure science be maintained. It is doubtful if the importance of maintaining the full interest in theoretical science of a laboratory staff has been fully realised. When the men come to the laboratory they are usually interested chiefly in the progress of pure science, but they rapidly become absorbed in the special problems presented to them, and, without definite effort on the part of those responsible for the direction of the laboratory, there is great danger that they will not keep up to date in what is being done by other workers in their own and allied fields. Their interest can be stimulated by journal meetings and scientific conferences, but the greatest stimulation is afforded by the requirement that they themselves should publish in the usual scientific journals the scientific results which they may obtain. Another reason for publication is that when a piece of work is written up for publication the necessity for finishing loose ends becomes manifest, and that work which is published is therefore more likely to be properly completed.

With some laboratories publication is rendered difficult by the industrial organisation; while nominally manufacturing companies are usually willing that results of scientific interest should be published, the organisation of the company frequently requires that they should be passed on by the heads of several departments, such as the sales, patent, advertising, manufacturing, and so on, and the heads of these departments, possibly not understanding the subject, and being afraid of passing material which might prove detrimental, frequently err very much in the direction of withholding entirely harmless information from lack of sufficient knowledge. It is much more satisfactory, if possible, for one responsible executive to pass on all matter submitted for publication, and this will inevitably result in a much more liberal policy than where the responsibility is delegated to a number of representatives of different departments of the company.

In addition to these scientific papers special technical reports for the information of the staff of the company itself should be circulated by the laboratory, and in the case of the Kodak laboratory an abstract bulletin is published monthly giving information as to the more important papers appearing in the technical journals associated with the photographic industry and also of all photographic patents. It is often advisable, also, to prepare special bulletins dealing with the application of scientific investigations, which have already been published, to the special needs and interests of the company.

Since the evidence points, therefore, to the establishment of really large research laboratories as the most economical and efficient way of increasing the application of science in industrial work, the question arises as to how these large laboratories are to be supported. In the United States the great manufacturing corporations, who can afford the necessary capital and expenditure for maintenance, and are willing to wait for the results, have already undertaken the establishment of a number of large research laboratories. Such concerns as United States Steel, General Electric Company, United States Rubber, Du Pont de Nemours, and many others are supporting large and adequately equipped research laboratories, the staffs of which are engaged in work on the fundamental theory of the industries in which they are interested, and undoubtedly more and more such laboratories will be established in the course of the struggle for increased industry which the United States is preparing to wage. There are a large number, however, of smaller firms, who cannot afford the great expenditures involved, but who are anxious to benefit by the application of science to their work, and it seems that the only solution of the problem of providing for such firms is in the direction either of co-operative laboratories serving the whole industry, as has already been done in the case of the National Canners' Association and the National Paint Association, and no doubt in some others, or of national laboratories devoted to special subjects connected with industry and corresponding to such institutions dealing with special branches of pure science as the Geophysical Laboratory of the Carnegie Institution. Schemes for industrial scholarships tenable at universities do not meet the case at all, since work done under such arrangements must necessarily be directed towards a definite practical end rather than towards the general acquisition of knowledge connected with the underlying principles on which an industry rests. In the same way consulting laboratories, like industrial scholarships, are interested in the development of results for immediate practical application, and both these methods of work are substitutes for the practical industrial laboratories belonging to my second general division rather than for the large laboratories here discussed.

In England the co-ordination of industry has not proceeded as in the United States, and there are very few corporations who would be willing to maintain a large, fully equipped research laboratory of the type discussed, although a few such laboratories are well known to be in existence, but British industry has been brought very much together during the past eighteen months, and the organisation of industry is already a familiar phrase. Why, then, should England not establish a National Industrial Research Laboratory to assist all British manufacturers, and to develop the theory underlying the great fundamental industries on which British work depends? Such a laboratory could take the theory from the universities, or, where the theory was lacking, develop it and apply it to the separate industries, working out the results on a semi-manufacturing scale, and finally passing it on to the manufacturer. It may be of interest to glance at the possible size and scope of such an organisation, and I have attempted to formulate a scheme which will represent the minimum which would be required.

A laboratory on the smallest scale adequate to British industry would, at the beginning, require a staff of about two thousand men, one thousand of them scientifically trained and the other thousand assistants and workmen. It should have about three or four hundred men of the rank of professor or assistant professor in the universities, or of works manager or assistant manager or chief chemist in the factory. It would require land and buildings costing about 600,000*l.*, and its annual upkeep with allowance for expansion would be about 800,000*l.*

Vast as these figures are, they are infinitesimal compared with the value of the industries which they would serve. They represent a charge of less than 1 per cent., and probably not more than 1/5th per cent., of the net profits of British industry; moreover, after the initial period had been paid for, such a laboratory might be self-supporting, and might, indeed, finally make a very handsome profit on the original investment.

Suppose that such a laboratory patented all inventions and licensed manufacturers to use them, then I think, it is not too much to expect that after the first five or six years it would be paying for itself, and that five years later it would be able to establish a great many subsidiary institutions from its profits; at any rate, such a vast laboratory would produce far more results at lower cost than would result from any other expenditure of a comparable sum of money on industrial research by the British industries.

I believe, however, that within the lifetime of most, if not all, of us we shall see such extensions of industrial research as will make all that we now have in mind seem insignificant, and it is because I believe so strongly in the importance of the subject that I have endeavoured to collect some impressions on the subject and to bring them before you this evening.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

London.—At the assembly of faculties of University College on July 6, Dr. G. Carey Foster in the chair, the provost's report on the session 1915–16 was read. In addition to the services rendered in the Navy and Army by members of the college, laboratory and workshop accommodation has been utilised for various forms of war work. It is not permitted to give detailed particulars of the work done; but the departments that, from the nature of their work, have been particularly active are those of physics, chemistry, physiology, pharmacology, applied statistics and eugenics, and all the departments of the faculty of engineering. The effect of the war upon the college finances has been a cause of grave anxiety. This has been to some extent mitigated by a grant from the Treasury of 10,500*l.* and by the economies that it has been possible to introduce owing to the unsparing efforts of members of the academic staff in this direction, and owing also to the friendly co-operation of other London colleges, more especially King's and Bedford Colleges. The chief domestic event of the year is the occupation of the new chemistry laboratories. They are well on the road towards completion, but much equipment is still needed, and can only be provided as the means are forthcoming. Towards the sum of 20,000*l.* still required for this purpose, the benefactor, Sir Ralph Forster, to whom the college is largely indebted for the new chemistry buildings, has promised a sum of 5000*l.* provided the balance of 15,000*l.* is speedily subscribed.

The Executive Committee of the Household and Social Science Department of King's College for Women has appointed Miss Lane-Claypon to be the chief administrative officer of the department under the committee, with the title of dean. This office will be combined with that of lecturer on hygiene. The committee has decided upon this new appointment with the view of meeting the rapidly growing needs of the department. Dr. Lane-Claypon, who is at present an officer of the Local Government Board, will take up her duties next session.

Manchester.—The total number of students in all faculties for the session just concluded was 1165. In the sessions 1913–14 and 1914–15 the numbers were 1654 and 1415 respectively. The list of past and present members of the university serving with H.M. Forces in the war, or engaged in approved war service, now numbers more than 1300. The number of past or present members of the university killed in action, died through the war, or reported missing has now reached 90.

Many of the departments of the university have been able to render special scientific service both advisory and experimental, in connection with the war. Prof. Petavel is a member of the Government Advisory Committee on Aeronautics, and all the work now being done in the department of engineering under his direction has a bearing upon war problems, and is being placed at the service of the Government. Prof. Dixon has been appointed deputy-inspector of high explosives for the Manchester area, and all the high explosives manufactured in the district are tested in the university chemical laboratory. Prof. Lapworth has been authorised by the Ministry of Munitions to conduct a number of war researches, and a staff has been organised in his department for testing tars made in various gasworks in the country. Prof. Edwards and his assistants in the metallurgy department have been fully engaged in testing work for the Admiralty.

Sir E. Rutherford is a member of the Board of Investigation and Research of the Admiralty, and special investigations are in progress in the physics department dealing with the problems that engage the attention of that Board. The testing of optical instruments for the Ministry of Munitions is also carried on in that department.

In the school of technology a large staff of teachers and student is engaged in various kinds of work for the Ministry of Munitions and other departments of the Government.

Prof. Chapman has been appointed by the Board of Trade, and Profs. Calder and Dickie by the Admiralty, for special service in these Government departments. War work is also being conducted in the botany department for the Royal Aircraft Factory, and by Prof. Beattie in the department of electrotechnics.

The women teachers and students have organised two V.A. detachments of the Red Cross Society, and have been engaged in other forms of work for the relief of the sick and wounded soldiers in the Manchester hospitals.

Several of the elementary schools having been taken over for military hospitals, the museum committee, in consultation with the education authorities, has made arrangements for classes of students to be given in the natural history and Egyptology departments of the museum. By this arrangement effective instruction is provided for 900 to 1000 children per week in the museum.

The next general meeting of the Association of Public School Science Masters will be held at Eton, under the presidency of Prof. H. H. Turner, on January 3 and 4, 1917.

The trustees of the Beit Fellowships for Scientific Research, which were founded and endowed three years ago by Mr. Otto Beit, in order to promote the advancement of science by means of research, have elected to fellowships for 1916–17: Mr. H. N. Walsh, Cork (extension for a second year); Mr. W. A. Haward, Tufnell Park; and Mr. C. C. Smith, Bristol. The three Fellows will carry on their respective researches in the Imperial College of Science and Technology.

The issue of the *Times* for July 15 gives some particulars of a meeting on July 6 between the parents of boys at twenty-six of the principal public schools and a committee of public school headmasters. The attitude taken up by some of the headmasters showed a misapprehension of the claims made by the champions of the value of a training in science in the education of all. To study science is not of necessity to become materialistic, and science and materialism are not by any means synonymous terms, though one headmaster argued as if they were. The man of science values as much as others high-mindedness and real character, but he urges that these may be secured side by side with an acquaintance with modern science and general efficiency. The headmaster of Harrow explained that in his school all boys are compelled as